Quantifying the Earthquake Hazard and Risk in the Sacramento-San Joaquin Delta – How Bad Can It Get

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7th Annual Northern California Earthquake Hazards Workshop
Meno Park, CA
26 January 2010

Introduction

- The effects of earthquakes may be the most significant natural hazard that can impact the Delta levees.

- As part of the Delta Risk Management Strategy Project (DRMS), a probabilistic seismic hazard analysis (PSHA) was performed to define plausible earthquake ground shaking events that will contribute to the risk of levee failure in the Delta.

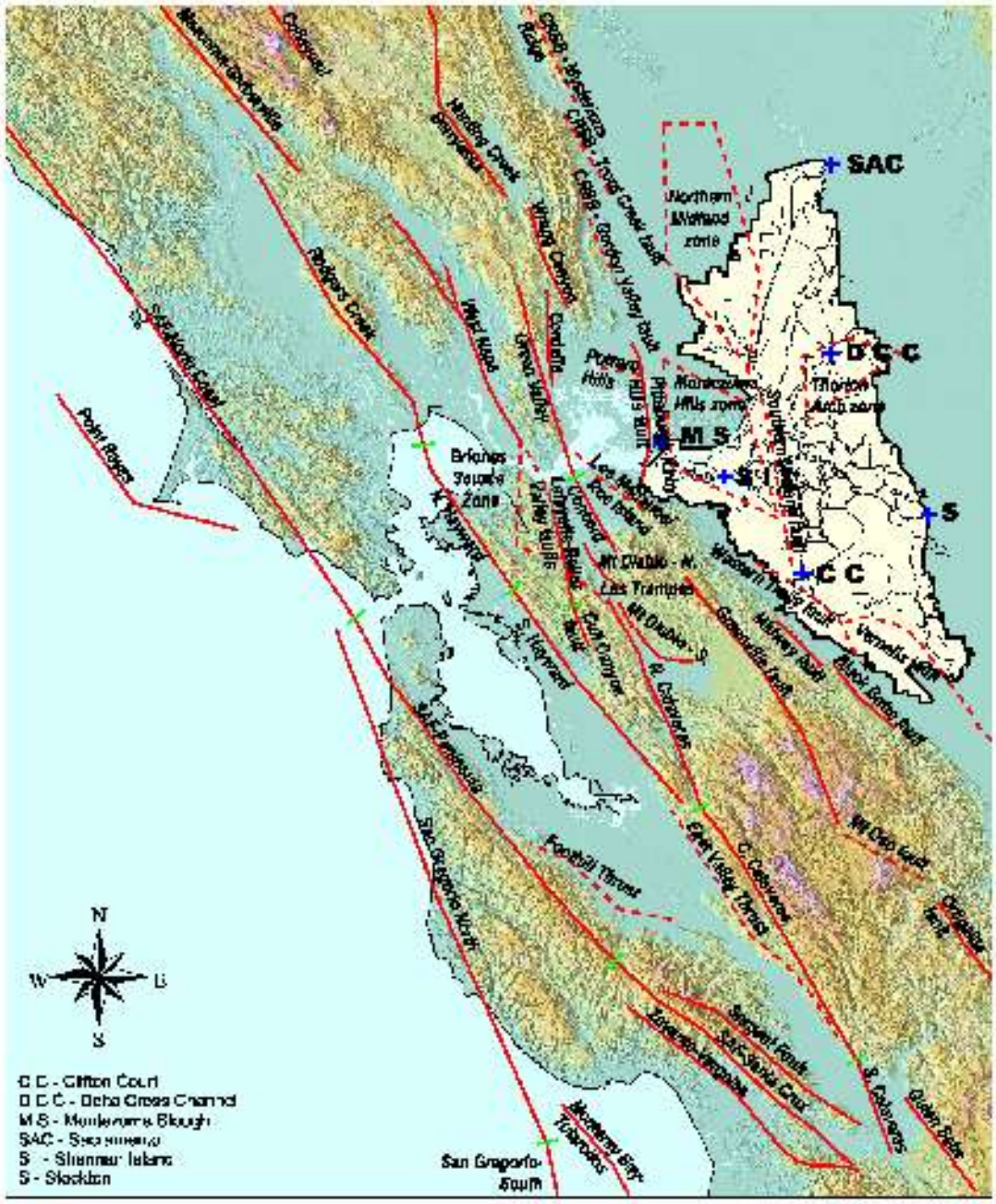
Introduction (cont'd.)

- These events are used to develop estimates of risk (defined as the annual probability of seismically-induced levee failure) at selected times over the next 200 years, e.g., 2005, 2050, 2100, and 2200.

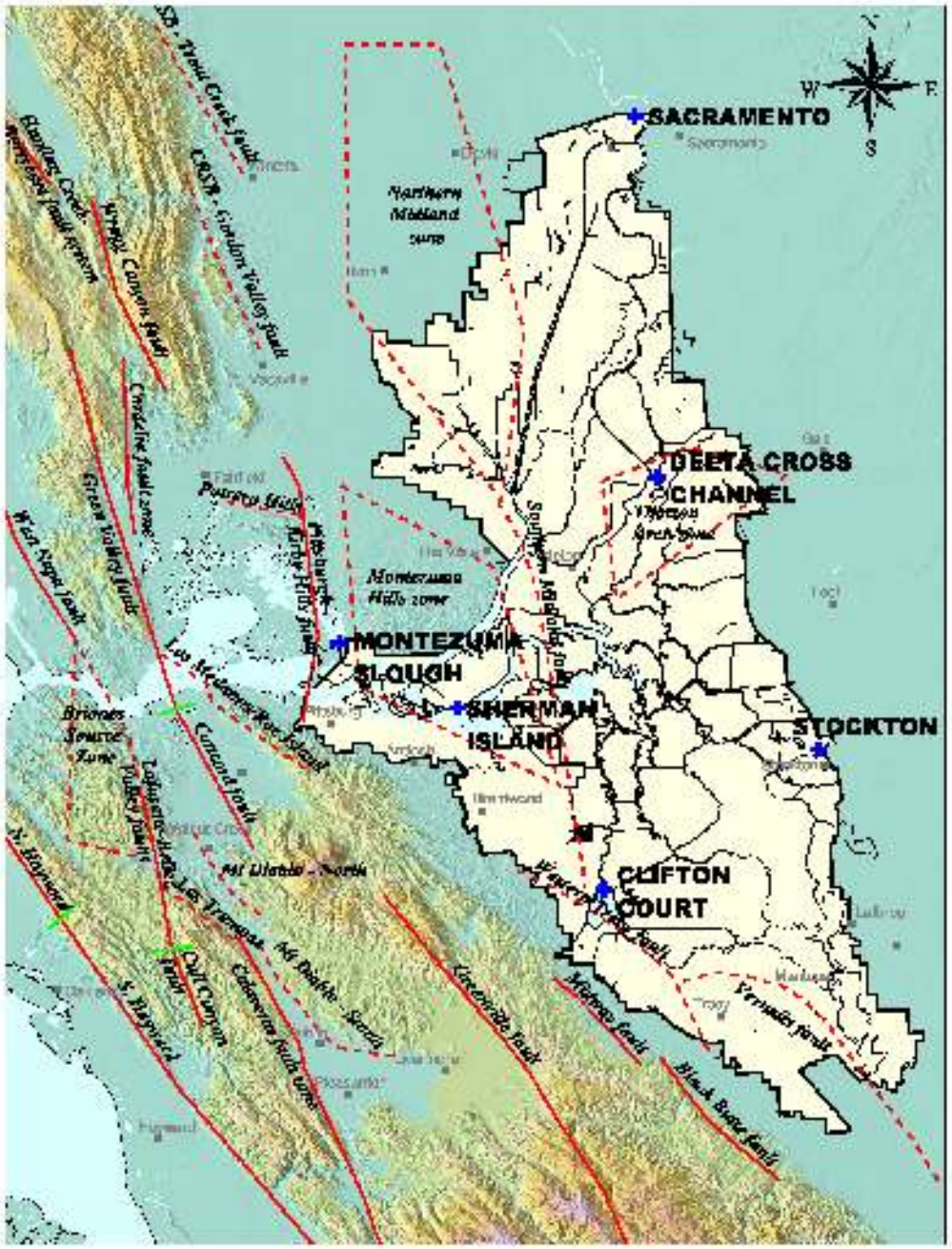
- The economic consequences of levee failure were also quantified.

- Given that selected times are of interest, the PSHA calculations incorporate the time-dependent behavior of the major faults characterized by the WGCEP (2003).

Seismic Sources in the San Francisco Bay Region



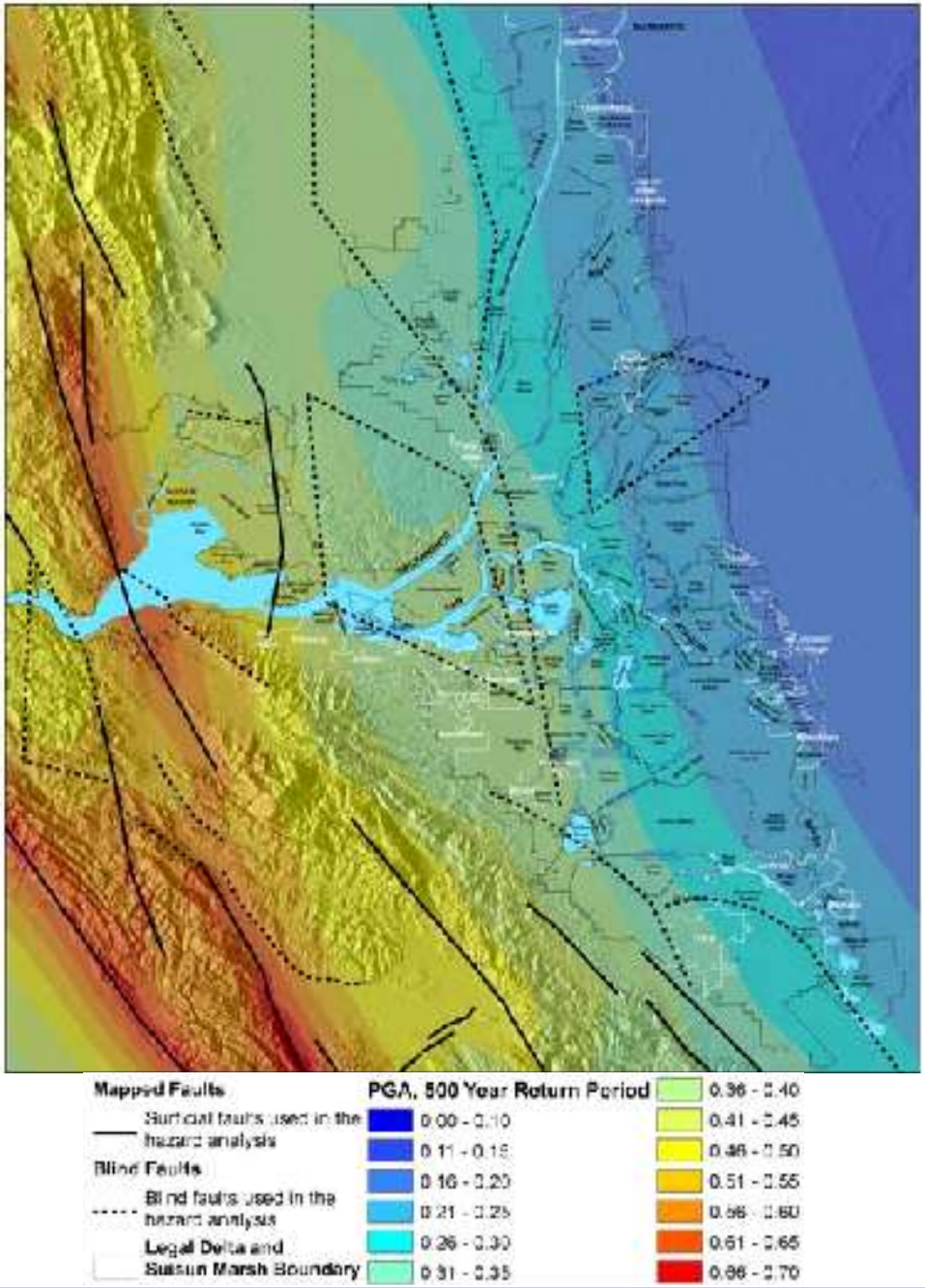
Seismic Sources In and Near the Delta



Seismic Source Issues in the Delta

- How is crustal deformation accounted for in the Delta?
- Are there blind faults?
- What is the role of the Midland fault?

PGA Hazard for a 500-Year Return Period for a Stiff Soil Site Condition



Summary of PSHA

- Based on the hazard results, a number of seismic sources contribute to the hazard in the Delta. One of the most important seismic sources is the Southern Midland fault, a buried structure we know little about.

- The major faults within the San Andreas system are not the most significant contributors to the probabilistic hazard (except at long periods, > 1.0 sec) because of their distance and the presence of the local Delta faults (e.g., Midland, CRSB, Pittsburg-Kirby Hills).

Summary of PSHA (cont'd.)

- The time-dependent and time-dependent hazard results are similar because the hazard in the Delta is controlled by the local faults.

- In a deterministic sense, a large earthquake (**M** > 7) anywhere in the San Francisco Bay region may still damage the levees.

- Time-dependent probabilistic ground motions for the six specific sites in the Delta had 2% in 50-year PGAs that range from more than 0.75 g on the west side to about 0.3 g on the east side in the Central Valley.

Summary of PSHA (cont'd.)

- The effects of the peat and softer soils were incorporated into the ground motions through site response analyses.

Frequency Distribution on the Number of Flooded Islands Due to Seismic Events

Levee Repairs - Cost and Duration

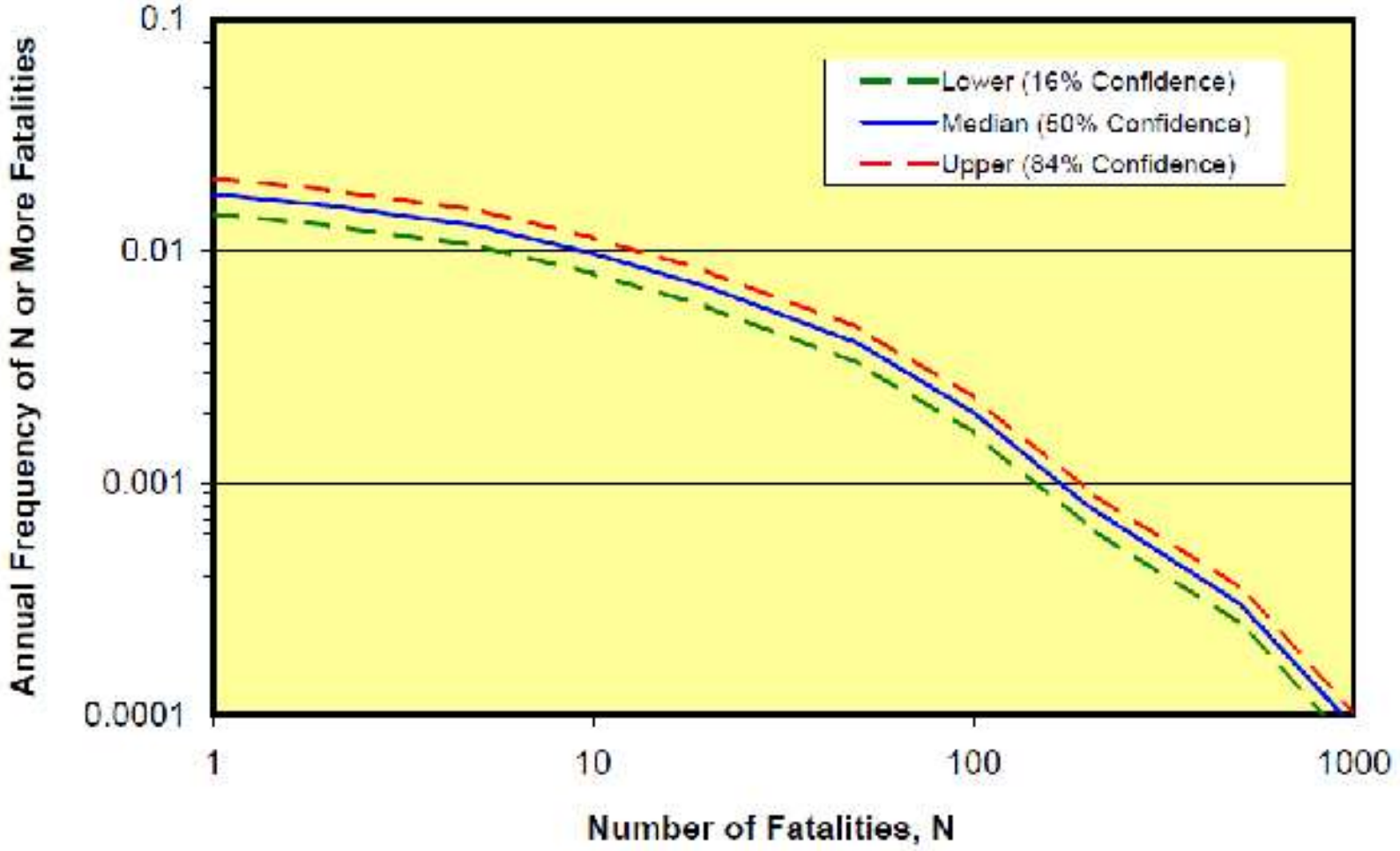
No. of Flooded Islands	Estimated Range of Cost of Repair and Dewatering ($M)	Estimated Range of Breach Repair Time (days)	Estimated Range of Time to Dewater (days)
1	43 240	27 106	136 276
3	204 490	120 330	270 466
10	620 1260	290 586	460 700
20	1,400 2,300	620 880	750 1,020
30	3,000 4,200	1,120 1,520	1,240 1,660

[a] The range is provided for plus and minus one standard deviation from the mean values.

Economic Consequences

Number of Flooded Islands	In-Delta Costs ($ Million)			Statewide Cost ($ Million)			Total Cost ($ Million)		
	Lower Estimate (16% Confidence)	Median (50% Confidence)	Upper Estimate (84% Confidence)	Lower Estimate (16% Confidence)	Median (50% Confidence)	Upper Estimate (84% Confidence)	Lower Estimate (16% Confidence)	Median (50% Confidence)	Upper Estimate (84% Confidence)
1	134	199	296	8	19	47	142	219	343
3	436	647	961	63	154	376	499	801	1,337
5	775	1,150	1,706	200	489	1,196	974	1,638	2,902
10	1,741	2,584	3,835	1,061	2,596	6,354	2,802	5,180	10,189
15	2,900	4,304	6,387	3,026	7,406	18,127	5,926	11,710	24,513
20	4,060	6,024	8,939	4,991	12,216	29,899	9,050	18,240	38,839
30	7,187	10,665	15,826	6,032	14,763	36,135	13,219	25,428	51,961
50	11,247	16,689	24,766	11,022	26,979	66,034	22,269	43,668	90,800

Life Loss Risks Due to Seismic Events

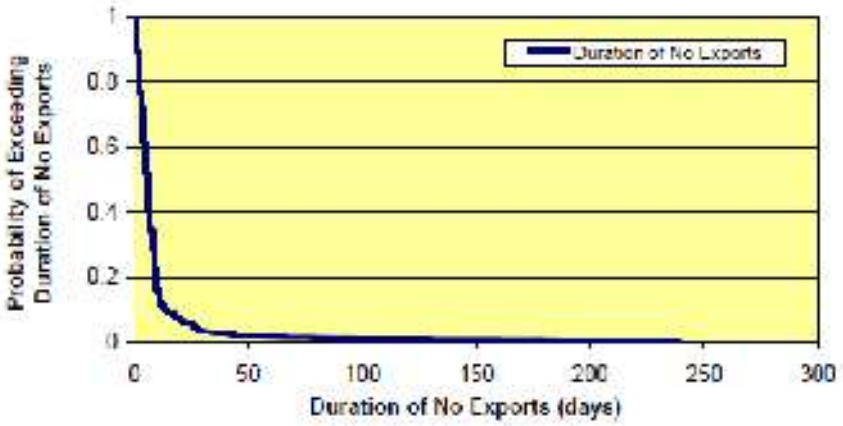


Ground Motions With a 2% Exceedance Probability in 50 Years (2,500-Year Return Period)

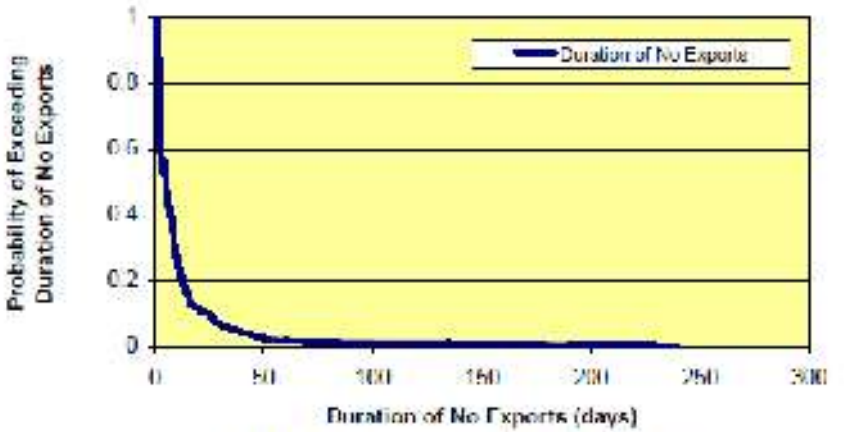
Peak Ground Acceleration (g)

	TI	2005	2050	2100	2200
Sherman Island	0.64	0.64	0.64	0.64	0.65
Clifton Court	0.66	0.66	0.66	0.66	0.67
Montezuma Slough	0.75	0.74	0.74	0.74	0.75
Delta Cross Channel	0.38	0.37	0.37	0.37	0.37
Stockton	0.33	0.32	0.32	0.32	0.33
Sacramento	0.30	0.30	0.30	0.30	0.30

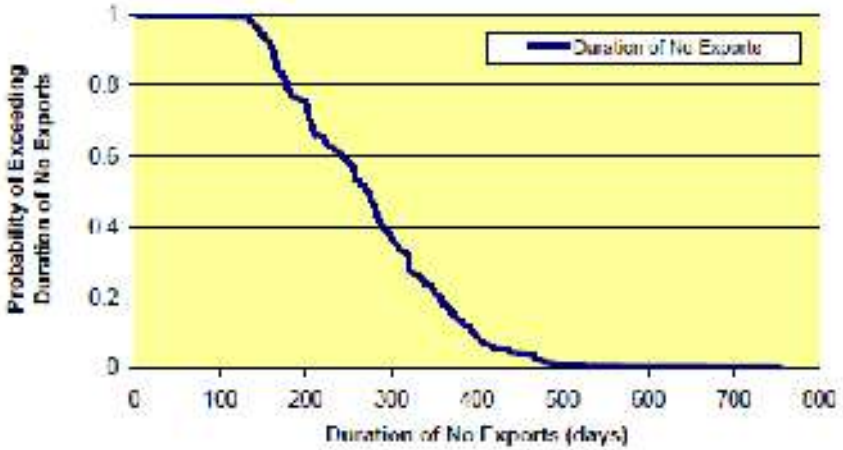
Impact on Water Exports



a. Three Flooded Islands; "Normal" Hydrology



b. Three Flooded Islands; "Varied" Hydrology



c. Twenty Flooded Islands; "Normal" Hydrology

d. Twenty Flooded Islands; "Varied" Hydrology